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BOULENGER,[16] from observations of the evening primroses growing wild at South Kensington, England, and in La Garde St. Cast, Brittany, concludes that *O. Lamarckiana* and *O. biennis* cannot be distinguished as separate "species," and that *O. Lamarckiana* originated from *O. biennis* through some hypothetical process of hybridization among the different forms of the latter. His conclusions rest on an examination of the variability of the plants taken *en masse* in the wild condition, and the unproven assumption that all the plants observed at St. Cast, Brittany, came from a single stock. Many different forms, both in Europe and America, go under the name of *O. biennis*, as MACDOUGAL has shown, and if *O. Lamarckiana* were capable of giving rise to any of these we might have expected to find them in DEVRIES' cultures. The study of the Oenotheras has long since reached the stage where cultures are necessary to determine the relationships of the various strains, and without such studies speculations drawn from casual observations of variability among forms growing wild are not likely to affect seriously the results obtained from culture work such as that of DEVRIES.—R. R. GATES.

A biometric study of Ceratophyllum.—A recent memoir by PEARL[17] on variation and differentiation in Ceratophyllum presents an admirable illustration of the successful application of mathematics to the working-out of important biological problems. The work is too compact to allow a brief review to present all the important relations which are clearly demonstrated by biometric analysis of the variation in the number of leaves in a whorl as related to the position of the whorl on the plant. It is shown that the whorls on each grade of branches, e. g., main stem, primary, secondary, tertiary, etc., are differentiated as a class from each other grade by several distinctive features of their variability. In all these grades the correlation between number of leaves in a whorl and its position on the stem is considerable. It is least in the main stem and increases as we pass to the more peripheral divisions. The regression line is not linear, but logarithmic, being of the type $y=A+C\log(x-a)$, in which A, C, and a are constants, y is the number of leaves per whorl, and x the position of the whorl. The curves so derived fit beautifully the observed data, and allow the derivation of what is believed to be a very fundamental biological law which is called the "first law of growth" in Ceratophyllum, and is stated thus: "On any axial division of the plant the mean number of leaves per whorl increases with each successive whorl in such a way that both the absolute increment and the rate of increase diminish as the distance (measured by the number of nodes) of the whorl from a fixed point increases."

By the fact that the equation fits data from plants collected from different habitats, by merely changing the factor A which represents the actual size and not at all the size of parts relative to position, it is shown: (1) that A is the environmental factor, and (2) that environment affects size but not at all the progress of differentiation represented by the logarithmic curve. It is found that the curve for the main stem is most nearly horizontal and that for each successive grade of branches is steeper and steeper, a change in the curve dependent upon the increasing value of the constant C, which is therefore regarded as the constant which expresses the action of internal formative factors.

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[16] BOULENGER, G. A., On the variations of the evening primrose (*Oenothera biennis* L.). Jour. Botany **45**:353–363. 1907.

[17] PEARL, RAYMOND, assisted by OLIVE M. PEPPER and FLORENCE J. HAGLE. Variation and differentiation in Ceratophyllum. Carnegie Institution of Washington, Publ. no. 58. pp. 136. *pls. 2. figs. 26.* 1907.

On any axial division the first whorls are the most variable in number of leaves, and this variability decreases at first rapidly, then less and less rapidly as more and more distal positions are reached, the theoretical limit attained being perfect constancy. This constitutes the "second law of growth" in Ceratophyllum. It is shown that these two laws are true in branch production as well as leaf production in this species.

Although few other studies have been made which can be definitely cited to demonstrate the general validity of these two laws of growth, the essence of the second law was recognized by the reviewer[18] in the case of *Sium cicutaefolium*, and other published observations are mentioned which appear to indicate that these are general laws. It is believed that this second law is the same which in the physiological field has been stated by JENNINGS[19] thus: "An action performed or a physiological state reached is performed or reached more rapidly after one or more repetitions, so that in time it becomes 'habitual.'" It is shown that in psychology it is probably the same law that lies at the basis of memory, namely, the ease, as measured by rapidity and accuracy, with which a state once reached is reached again. It seems probable, at any rate, that suitable analysis of all these cases will show that they are governed by logarithmic laws, and though no suggestion has been made as to the nature of the common causes upon which such general validity of the logarithmic law must rest, their nature will doubtless be brought to light very soon when once it is recognized that they exist.

The necessity of more studies of a similar nature is apparent. It is important to know how these laws are affected by more complex environmental conditions. The ease and conclusiveness with which they were demonstrated in Ceratophyllum probably depended upon the fact that in this species environmental modifications are reduced to their lowest terms. It is to be hoped that the aims and methods of this paper may serve as guides for many biometric studies, for the successful analysis of the laws of differentiation within the individual must precede studies which involve repeated structures in different individuals. Studies of the latter type are insecure until the laws of intra-individual differentiation and variation are known for the particular species of plant or animal under investigation.—GEO. H. SHULL.

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[18] SHULL, G. H., Stages in the development of *Sium cicutaefolium*. Carnegie Institution of Washington, Publ. no. 30. pp. 28. *pls*. 7. 1905.

[19] JENNINGS, H. S., The methods of regulation in behavior and other fields. Jour. Exp. Zool. 2:473–494. 1905.